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The E781 (SELEX) RICH Detector

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Abstract

First results from a new RICH detector, operating in an experiment currently taking data - Fermilab E781 (SELEX), are presented. The detector utilizes a matrix of 2848 phototubes for the photocathode. In a 650 GeV/c π^- beam the number of photons detected is 14 per ring, giving a Figure of Merit N_0 of 106 cm^{-1}. The ring radius resolution obtained is 1.2 %. Results showing the particle identification ability of the detector are discussed.

1 Introduction

The experiment E781 (SELEX): A Segmented Large x_F Baryon Spectrometer, currently collecting data in a fixed target run at Fermilab, is designed to perform high statistics studies of production mechanisms and decay physics of charmed baryons such as Σ_c, Ξ_c, Ω_c and Λ_c.

The physics goals of the experiment require good charged particle identification to look for the different baryon decay modes. One must be able to separate π, K and p over a wide momentum range when looking for charmed

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baryon decays like $\Lambda_c^+ \rightarrow p\, K^- \pi^+$. A RICH [1] detector with a 2848 phototube photocathode array has been constructed [2] to do this.

2 Detector

- **Vessel and Gas System** The radiator is 10 m long and 2.4 m in diameter, filled with neon at 1.05 atm. To fill the vessel [3], there is an initial purge with CO_2. Then the CO_2 is removed by freezing while neon is added. Activated charcoal adsorbers remove the remaining small amounts of O_2 and H_2O. Because special care was taken to make the volume gas tight, the index of refraction of the gas has remained almost constant, varying about 1 part per thousand per month. In addition, the O_2 content has only changed by 3 ppm in nine months of operation.
- **Mirrors** The spherical mirror system consists of 16 hexagon-shaped glass mirrors, 40 cm across and 1 cm thick. They have an average radius of curvature of 20 m with an RMS spread less than 5 cm [4]. The mirrors are mounted in an array which is approximately 2 m wide and 1 m high, fixed to a low mass hexcel panel with 3 point kinematic mounts. A first rough alignment was done by eye. The final alignment was done with a laser mounted on a theodolite base, sited at the center of curvature. The mirror positions were adjusted until the reflected spot observed back at the center of curvature had no more than 2 mm displacement.
- **Photon Detection** The photon detection system consists of 3 parts:
  - **The holder plate** supports the phototubes arranged in an hexagonally close-packed matrix of 89 x 32 tubes, provides a gas seal via 2848 individually glued quartz windows and holds aluminized mylar Winston cones for each phototube, resulting in essentially 100 % coverage for detecting photons.
  - **The phototubes,** of which two different types of one-half inch diameter, 10 mm bi-alkali photocathode tubes are used. The first is a commercially available tube from Hamamatsu (R760) which has a quartz window and thus response down to 170 nm. The second is a Russian tube (FEU60) which was coated with PTP wavelength shifter to reach the same wavelength range. (The quartz entrance window of the holder plate provides the 170 nm cutoff.) The FEU60 tubes have an average efficiency of 42 % compared to the R760 phototubes. Tubes are grouped by operating point so that each column of 32 tubes can be run at the same high voltage. The central, high momentum section of the photodetector has both types of tubes, with FEU60 tubes only in the outer sections.
  - **Readout** consists of hybrid chips which combine an amplifier, discriminator and a differential ECL line driver. The digital output from the chips is stored in latches [5]. The readout is mounted externally to the photocathode box for easy servicing. Signals from the phototubes are routed to

the chips via a light-tight backplane using Euro-connectors.

3 Detector response

Figure 1 demonstrates the detector response to 650 GeV/c π^- single beam tracks. The left histogram shows the number of photons detected in each event. From this one can calculate for the central region of the detector the Figure of Merit N_0, which is defined by the relation [6] $N_0 = N/(L \sin^2\theta)$, where N is the number of detected photons, L is the radiator length and θ is the Cherenkov angle. For this detector N_0 is $106\,\mathrm{cm}^{-1}$. The single track ring radius resolution is given in the right histogram as 1.36 mm, or $\sigma/R = 1.2\,\%$. This resolution should give useful π, K separation out to about 200 GeV/c.

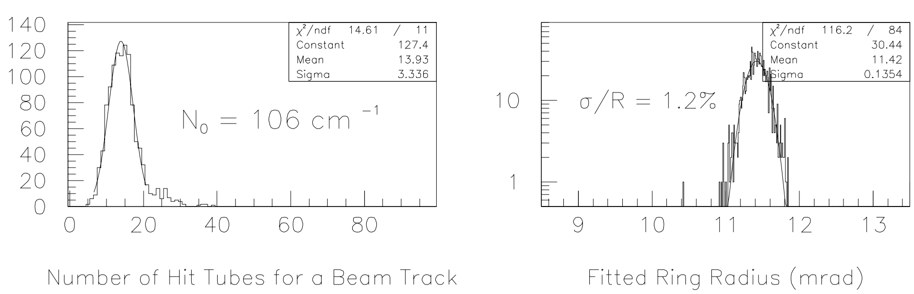

Fig. 1. Detector response to single beam tracks. The left histogram shows the number of detected photons for each event. The right histogram is the measured ring radius distribution.

Figure 2 is a single event display which demonstrates the low noise of the detector (average 6 hits for beam off events) and its clear multi-track capability. A maximum likelihood analysis [7] is performed for each track in the event. The algorithm uses tracking information for the ring centers and then examines hypotheses for several different particle types for each track. For example, track 5, with momentum of 180 GeV/c, has been identified as a proton with likelihood more than 100 times that for being a pion, kaon or heavier mass particle.

Figure 3 demonstrates the power of good particle identification. The histogram at the left is the effective mass of all unlike sign pairs of tracks within the RICH acceptance, assuming that both tracks are kaons. The central histogram has one of the two particles identified as a kaon in the RICH, the rightmost histogram has both particles identified. The ϕ peak clearly stands out.

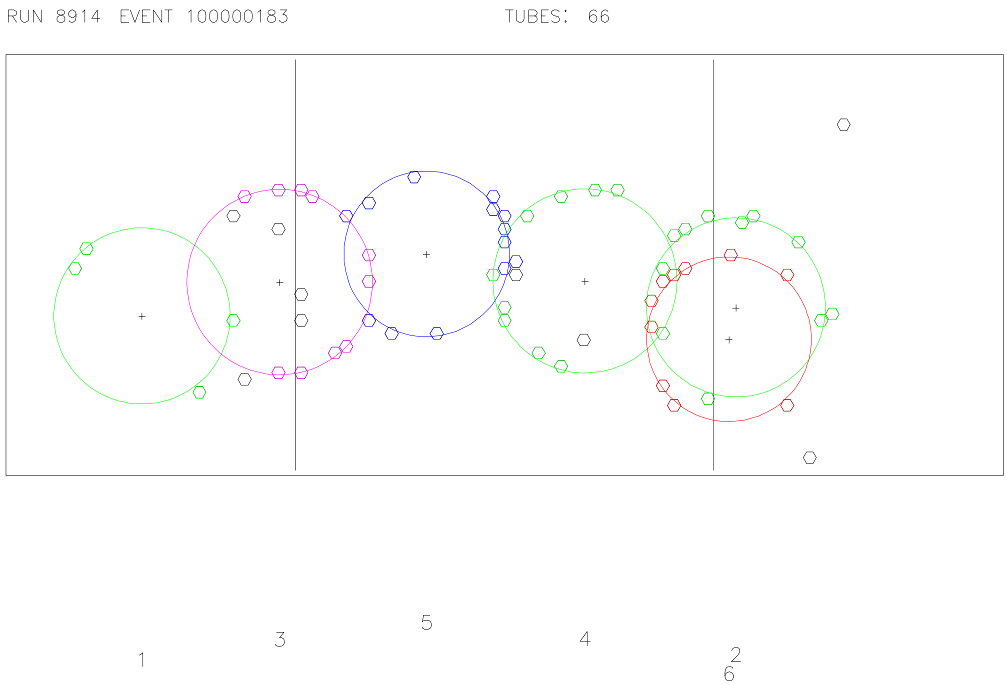

Fig. 2. Single event display.

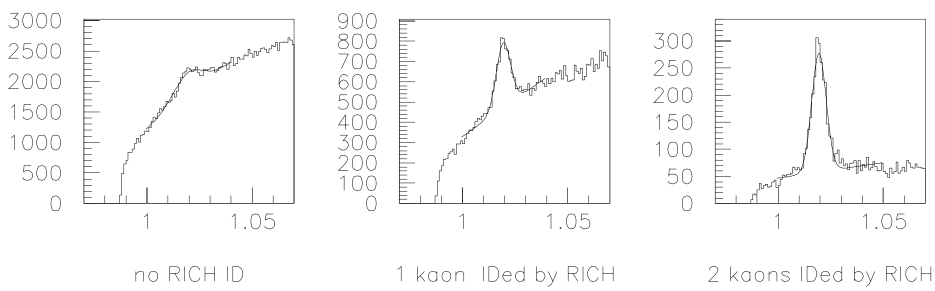

Fig. 3. Effective mass of unlike-sign pairs within the RICH acceptance assuming that they are kaons. Left: all pairs, Center: one particle identified as a kaon in the RICH, Right: both particles identified as kaons in the RICH.

4 Conclusions

The E781 (SELEX) RICH detector has successfully come online and is already contributing to physics results. It has high efficiency, with a measured N_0 of 106 cm^{-1}. The ring radius resolution is 1.2 %, which should give useful π, K separation out to about 200 GeV/c.

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